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OPTICAL FLUORITE IN SOUTHERN ILLINOIS

BY

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OPTICAL FLUORITE IN SOUTHERN ILLINOIS

By Joseph E. Pogue[1]

INTRODUCTION

Fluorite, or fluorspar as it is commonly called, is a mineral of rather limited occurrence, used in bulk in this country in the manufacture of steel, hydrofluoric acid, enamels, glazes, and for a few other purposes. In addition, clear, colorless, or faintly colored specimens, such as occur rather sparingly in some localities along with the crude material, are suitable for the manufacture of certain types of lenses and prisms employed in microscopes and other optical instruments. Although the largest known deposits of fluorite in the world occupy a belt of country extending from southeastern Illinois into western Kentucky, but centering in Hardin County, Illinois, the availability for optical use of the product from this region has heretofore been neglected, and the United States has been dependent upon foreign sources for its material, which came largely through the hands of German optical dealers.[2]

In connection with a recent geological survey of the fluorspar deposits of southern Illinois, the State Geological Survey with this application in mind has determined the presence of optical fluorite of excellent quality and in quantity probably sufficient to supply the needs of the United States. This report is published for the purpose of bringing the matter to the attention of the industries concerned, with a view to stimulating a suitable production, now particularly needed as a result of the cutting off of foreign supplies by the war. The report is designed to be nontechnical in character and to supply the information essential to a proper development of this resource.

PROPERTIES, USES, AND VALUE OF OPTICAL FLUORITE

Each transparent mineral not only bends or refracts rays of light in a definite and characteristic manner, but bends the colored components of the individual rays at slightly different angles—a property called dispersion. In addition to this, most minerals break light into two rays, each of which is both refracted and dispersed; only minerals that crystallize in very symmetrical forms, such as cubes or octahedrons, do not show this double refraction. Fluorite bends light very slightly (has a low index of refraction); disperses light faintly (that is, its refraction of red rays differs only a little from its refraction of yellow rays and so on); and normally displays no double refraction. These three properties place fluorite in a unique position among minerals and fit it for a highly specialized optical use which no other mineral or artificial substance can meet equally well. Only three or four other minerals have lower refraction than fluorite; but these are either colored or are not sufficiently transparent, and moreover show marked double refraction as a result of their crystallization. Hence fluorite stands alone.

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[1] In the field investigation upon which this report is based, the writer was assisted by L. W. Currier.

[2] Only two foreign sources of optical fluorite are known to the writer; these are Meiringen, Switzerland, and Obira, Bungo, Japan.

Glass, of a special kind, is the dominant material used in all optical apparatus. By varying the chemical composition of the glass and the shape of the lenses and prisms made from it, the various optical effects desired are obtained. Owing to the reflection of light from surfaces and a breaking up or dispersion of light in passing through a substance, errors are introduced, and to neutralize or minimize these errors calls for the best efforts of technical art and scientific knowledge. It is here that optical fluorite finds its chief use.[1] Due to its low refractive power and very weak color dispersion, this mineral is especially suitable for correcting the spherical and chromatic errors of lens-systems. The so-called apochromatic objective used with microscopes consists of a lens of fluorite placed between lenses of glass and represents the finest type of objective that optical art produces. There are two other classes of objectives, less fine and less costly, the *achromat* and the *semiapochromat;* fluorspar is used only in the second of these, which is a sort of compromise between the cruder achromat and the more nearly perfect *apochromat.* The less expensive semiapochromat could replace the apochromat in many instances, were optical fluorite more available; but at present the manufacturer is forced to conserve his meagre supplies of fluorite for use in making the finer and more expensive apochromats. It therefore appears that a plentiful supply of optical fluorite would be of great benefit to the microscope industry, as thus far the output of optical systems containing fluorite has been limited simply by an insufficient supply of this material. The development of adequate sources of optical fluorite therefore becomes a matter of considerable importance, affecting ultimately through cheaper and more efficient microscopes the progress of scientific and medical research.

Optical fluorite is also used in making prisms for spectrographs employed in ultra-violet work and for use in other optical apparatus in cases where great transparency to the ultra-violet and the infra-red parts of the spectrum is required. It is likewise employed as part of the lens-system in telescopes to correct certain color effects. Specimens suitable for such highly specialized uses as those mentioned in this paragraph are difficult to obtain, because of the comparatively large size of pieces required; but the demand for such material is rather limited in an economic sense, though very insistent and important for the furtherance of investigational activities. While practically all fluorite possesses the optical qualifications noted above, the vast preponderance of material is too strongly colored or else too clouded with internal fissures and inclusions to transmit light unaffected by these undesirable influences. Moreover, some clear and colorless specimens otherwise suitable for optical use are found to show an anomalous double refraction, due probably to abnormal conditions during crystallization, which renders them unfit. These incidental, rather than inherent properties, therefore, become the controlling factors in determining the availabilty of material, and consequently determine the practical specifications which prospective material must meet.

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[1] The writer is indebted to the Bausch and Lomb Optical Company, the Spencer Lens Company, and the Bureau of Standards for details in regard to the use of optical fluorite.

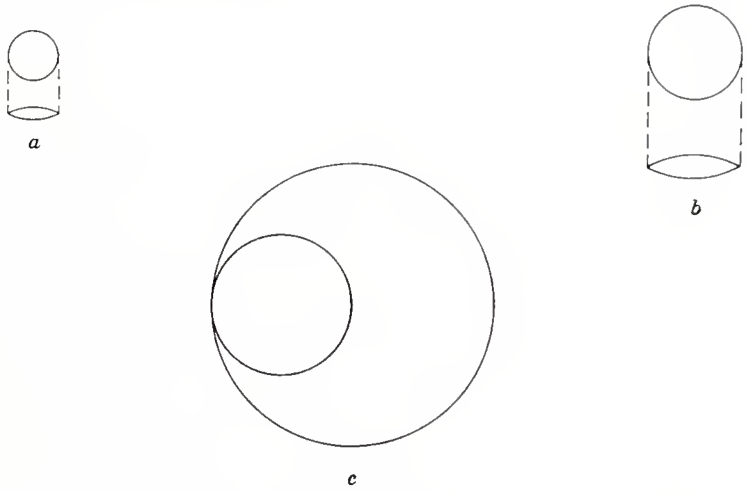

Fig. 1.—Sketch showing the sizes of finished products made from optical fluorite: *a*, top and side view showing approximate size of smallest fluorite lens in common use; *b*, top and side view showing approximate size of largest fluorite lens in common use; *c*, approximate sizes of optical fluorite pieces used in special investigations.

For optical use a specimen of fluorite must contain a portion at least one-fourth of an inch in diameter, free from flaws, and colorless or nearly so. Crystals, or pieces bounded more or less completely by plane surfaces, are more likely to qualify than irregular masses. As the surfaces of most crystals are dull, a corner of such a specimen should be broken off with a sharp blow so as to expose the interior. In doing this, it is desirable to rest the specimen on a wooden base and break off the corner along an incipient cleavage plane by means of a knife blade or chisel; such planes are usually present and may be located by moistening the specimen with kerosene. If the specimen looks promising, it is better to proceed no further, as fluorite is fragile and a misdirected blow will fill a clear piece with a network of fractures. A peculiarity of fluorite of optical quality is its conchoidal (irregularly curved) fracture and the absence of a strong tendency to break into pieces bounded by smooth planes in the fashion of the ordinary mineral.

An idea of the sizes involved may be gained from the accompanying figure, which shows the approximate sizes of the finished lenses. As to color, material that is absolutely water-clear is of course the most desirable, and in fact is essential for highly specialized uses; but faint tints of green, yellow, and purple do not in themselves render material altogether unsuited for optical use. Flaws must be lacking from the portion to be used, but flaws are present in the bulk of fluorite, due both to cracks (incipient cleavages) and to inclusions of bubbles or of visible impurities; accordingly the most detailed search is necessary to find pieces free from these objections. Moreover, careless handling, even jolts resulting from shipping, may develop flaws in clear material; hence the utmost care must be exercised in separating material of optical promise from its crude associations and in suitably packing such material.

The anomalous double refraction shown by some specimens, particularly by symmetrical crystal groups known technically as "twin-crystals," bars such material from optical use; but this property can be determined only by a microscope or other optical instrument at the eye of a trained observer. A clue to this condition is given in some cases by fine, parallel striations or rulings, marking a twinned condition of crystallization. In general, however, the clear specimens of southern Illinois fluorite already examined have been largely free from double refraction; hence for all practical purposes this test may be ignored in the field and left to the optical dealer to apply at his discretion.

The value of optical fluorite and the demand for it can not be expressed in definite figures, for the material is a specialized thing instead of a staple product. On the one hand, the demand will increase if optical fluorite can be produced at a figure sufficiently reasonable to warrant an enlarged utilization; whereas, on the other, an inflated price will destroy the opportunity for an increased demand. It must be remarked also that only a small portion, say 4 to 8 per cent on the average, of material classed as optical fluorite actually passes into the make-up of a lens-system, so much of the mass must be destroyed or discarded during manufacture. In other words, 25 pounds of good-looking, clear fluorite may produce no more than a single pound of finished lenses. Hence the value of the finished product comes only in part from the value of the raw fluorite entering into it; much of its value is introduced by the skillful work essential to its manufacture. These statements are to obviate the assumption that crude optical fluorite is of gem-value. In order to make the matter more specific, fluorite qualifying as optical in quality is worth a dollar or more a pound, while particularly large and fine specimens have an individual value of $10 and more apiece. These figures are rough approximations only, designed to give prospective producers a general idea of what their product may be expected to yield but not to be taken as quotations of market prices.

As to the quantity of optical fluorite that the United States consumes each year, it is likewise difficult to state, as this depends upon the quality of the crude material. But as prospective producers should have some idea of both the normal and the potential demand for their product, it may be assumed for this purpose that several hundred pounds of optical fluorite will meet the normal yearly demand, while this figure can perhaps be doubled or even more greatly increased if additional supplies can be reasonably produced.

OCCURRENCE OF OPTICAL FLUORITE

While ordinary fluorite is of common occurrence in the fluorite region of southern Illinois, it is only here and there that specimens of optical quality are found in association with the cruder material. While the presence of the optical fluorite seems to favor certain specific localities and to shun the large and extensively worked veins, a familiarity on the part of the mining men of the region with the requirements for optical use will undoubtedly bring to light further occurrences of promise.

The ordinary fluorite occurs in two ways: (1) as nearly vertical veins cutting bedded rocks along fault planes, and (2) as horizontal beds in part replacing limestone members of the bedded rocks. Optical fluorite has been found in association with each type of occurrence, but the second has thus far given the greater promise. Material of optical quality is more likely to be found as cubic crystals occupying the walls of small open spaces in the veins or beds, particularly in places where such cavities are relatively numerous and indicate a leisurely process of formation, than along with fluorite that is massive or tightly developed in the surrounding rock.

The mines and prospects that have been determined to contain material of optical quality are as follows:

The Cave in Rock mine, near Lead Hill, Hardin County, Illinois; operated by the Glass Brick Company, 241 Walnut St., Cincinnati, Ohio; a bedded deposit containing pockets lined with fluorite crystals, some yielding material of optical quality, colorless to faint yellow, and characterized by a conspicuous conchoidal fracture. This mine could probably be made to yield from one hundred to several hundred pounds of optical fluorite per year if continuously and actively worked.

Several prospects, or small mines, operating in 1917, on the west side of Lead Hill, in NW. ¼ SW. ¼ sec. 4, T. 11 S., R. 9 E., Shawneetown quadrangle, contain optical fluorite similar in character to that described above. One property is owned by the Lead Hill Lead and Spar Company; another by C. M. Miller, Basic Mineral Co., Pittsburgh, Pa.

The Pierce mine, in sec. 34, T. 11 S., R. 7 E., Equality quadrangle, operated by H. B. and Walter Pierce, Golconda, Illinois, has made shipments of optical fluorite in the past.

The Rose mine, in sec. 30, T. 11 S., R. 8 E., Equality quadrangle, not now (1917) operated; owned by D. C. Peyton, Indiana Reformatory, Jeffersonville, Indiana; contains some material of promise.

LIST OF PROSPECTIVE PURCHASERS

For the information of prospective producers of optical fluorite, the following names may be given as among the possible purchasers of this material:

Bausch and Lomb Optical Co., Rochester, N. Y.
Spencer Lens Co., Buffalo, N. Y.
Bureau of Standards, Washington, D. C.
Ward's Natural Science Establishment, Rochester, N. Y.

SUGGESTIONS AS TO DEVELOPMENT

The fluorite region of southern Illinois appears to be capable of supplying the needs of the United States in respect to optical fluorite. This will be accomplished if the mining interests of the region will give instructions to their mining staffs to search for and save all clear, glassy-looking specimens. No special knowledge is required to recognize material of promise. As compared with developed mines, the small mine or prospect has an equal if not a better chance of yielding good material, and hence the matter concerns the one-man operator as well as the larger mining company. Prospects in the neighborhood of Lead Hill should be examined with particular thoroughness, as this locality offers more than ordinary promise. Great care should be exercised in breaking large specimens for examination; also in further handling, packing, and shipping. Specimens for shipment should be packed in cotton, excelsior, or other resilient material, and placed in wooden, and not pasteboard, boxes. Samples of material of promise should be submitted to prospective purchasers before shipments are made. Particularly fine specimens will find a sale as single items; but the general run of optical fluorite should be offered for sale only in lots of several pounds or more.

For the proper development of this resource, which, though of limited value from a financial standpoint, is of considerable importance to society, the optical companies will bear in mind that the producers must be encouraged by a consistent price and at the outset be helped in discriminating between material of optical and common quality; while the producers will appreciate the fact that they are handling a highly specialized product, whose value can be more substantially enhanced by encouraging an enlarged demand through a suitable production than by limiting the supply and holding out for prices discouraging to the manufacturer.